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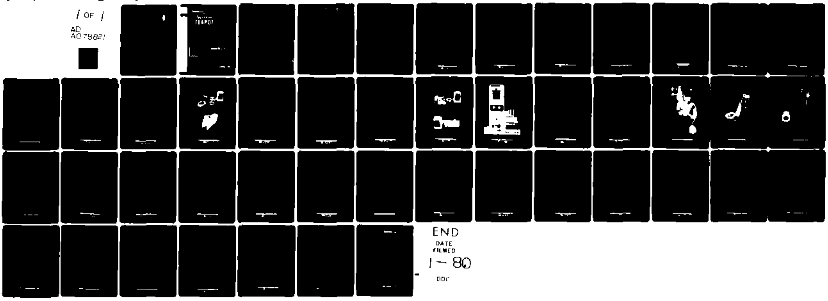

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PRELIMINARY REPORT

Operation TEAPOT

NEVADA TEST SITE

February – May 1955

ADA078821

Project 30.3

MEASUREMENTS OF BETA AND GAMMA RAY CHARACTERISTICS OF SHOT DEBRIS AND FALL-OUT OF NUCLEAR WEAPONS

Classification (Cancelled) [redacted] to UNCLASSIFIED
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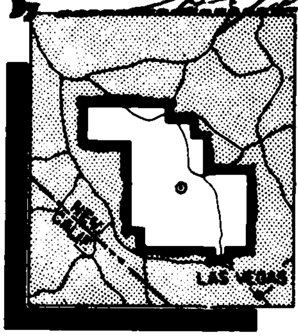

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No. 211 of 270 copies, Series A

Operation Teapot Preliminary Report

Project 30.3

MEASUREMENTS OF BETA AND GAMMA RAY CHARACTERISTICS OF SHOT DEBRIS AND FALL-OUT OF NUCLEAR WEAPONS

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New York Operations Office
U. S. Atomic Energy Commission

This is a preliminary report based on all data available at the close of the operation. The contents of this report are subject to change upon evaluation for the final report. Conclusions and recommendations drawn, if any, are tentative. The work is reported at this time in order to provide early test results to those concerned with effects of nuclear weapons and to provide for an interchange of information between projects for the preparation of final reports.

ABSTRACT

The distribution of fall-out debris and radiation intensities over wide areas may be rapidly surveyed from the air. The development of instruments and techniques must be based on consideration of the beta and gamma characteristics of the radioisotopic constituents of the fall-out material.

Radiation measurements in an aircraft may be related to surface conditions by an altitude correction factor, which has been determined by field measurements. To evaluate the mechanism of the absorption that this factor represents, both the gamma ray characteristics of the fall-out material on the ground and the gamma ray spectra in the air above the contaminated area were studied. A gamma spectrometer was developed for mobile operation in the field.

Surface conditions include a contribution to the total radiation field by beta rays. A beta energy spectrometer for laboratory measurements and a beta absorption instrument for field use were developed to allow study of the relationship between the beta and gamma radiation flux.

Development and field testing, during the Teapot series, has resulted in a group of instruments useful for study of the radiation characteristics of fall-out debris. An aerial survey detector with automatic altitude compensator and a telemetering unit was also completed and tested.

[redacted]

ACKNOWLEDGMENTS

This work was performed under the direction of R. L. Corsbie, Director, CETG, whose enthusiastic encouragement and leadership provided a means of accomplishing many of the more difficult tasks. We are especially grateful to R. Armstrong of the University of Rochester, who was of major aid during these operations and who took many of the spectra. Ira Whitney and H. J. DiGiovanni, of the AEC Health and Safety Laboratory, New York, also provided assistance and advice.

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CHAPTER 1

INTRODUCTION AND OBJECTIVES

1.1 INTRODUCTION

Previous field work of the Health and Safety Laboratory, U. S. Atomic Energy Commission, New York Operations Office, developed fast and accurate means of evaluating fall-out patterns by aerial surveys. An airborne radiation detector measures a gamma ray field which may be related to the radiation level at the surface. The aerial attenuation factor is based upon a number of observations taken over the last four test series. Closely controlled experimental conditions were required for further confirmation of the characteristic. The gamma ray field from a fission product contaminated pattern has an associated beta flux. New instruments were developed and tested which would allow better evaluation of the characteristics of this beta radiation.

1.2 OBJECTIVES

The objectives of this program were:

1. To develop techniques and equipment to measure gamma ray activity levels on the ground by means of airborne radiation survey equipment. To accomplish this fully, it is necessary to measure and evaluate the attenuation of the gamma ray flux from 3 feet above the surface to beyond 1000 feet.
2. To develop techniques for air-to-ground telemetering useful for transmission through commercial and military communications equipment.
3. To develop a portable gamma spectrometer so that gamma ray spectra may be evaluated on the ground and in the air above a contaminated area. Such data would be useful in determining the radiation factors on which to base the development of field instruments.
4. To collect onsite and offsite samples of shot debris soon after detonation for radiochemical analysis for the strontium-90 distribution. The analytical work is part of a HASL program which will be released separately. These samples will also be analyzed for gamma spectra as part of Project 30.3.
5. To measure beta-to-gamma dosage ratios for evaluation of biological effectiveness of the radiation fields.
6. To attempt to separate beta and gamma spectra by means of a scintillation detector and magnetic separation techniques for a study of the beta ray characteristic.

[redacted]

CHAPTER 2

EQUIPMENT

2.1 AERIAL SURVEY EQUIPMENT

This survey equipment consists of an aircraft borne radiation detector, HASL type TH-10-A, a military radar altimeter and the "Telepulse" telemetering system. The major sections of this unit are separated in the block diagram (Fig. 1).

2.1.1 Aerial Survey Unit

This equipment (Fig. 2) consists of a hermetically sealed scintillation counter head in which there are two complete detectors with plastic phosphors (Pilot Chemical Co., Waltham, Mass., Phosphor B). One phosphor, 3" diameter x 4" long, is used for measurements from 0.005 mr/hr to 100 mr/hr; the second, 1" diameter x 1/8" thick, is used for measurements from 10 mr/hr to 200,000 mr/hr. The head is connected to a remotely located control box where:

1. The direct data are taken by a graphic recorder (Esterline-Angus Co., Indianapolis, Indiana, Model AW) to provide a permanent record of the radiation in the airplane at the flight altitude.
2. Signals are picked off this recorder and passed through a network which converts the reading from two 5 decade scales (Fig. 3) to four 3 decade intervals (Fig. 4) having an overlap between decades.

Scale A - 0.01 to 1 mr/hr
Scale B - 0.1 to 100 mr/hr
Scale C - 10 to 10,000 mr/hr
Scale D - 1000 to 100,000 mr/hr

3. After passing through the range separation circuits, the signal is mixed with an altitude compensation factor derived from a radar altimeter. Ground level radiation is higher than that measured in the airplane because of the absorption in the air layer between the plane and the ground. The ground radiation can be computed from the plane reading by multiplying by a fixed factor for a specific altitude. These factors, as previously derived, are exponential in character (Fig. 5). Since the aerial radiation readings are on a logarithmic response scale, it is possible to provide a continuously compensated reading by electrically adding the absorption factor to the aircraft radiation data. The sum

of the two logarithmically expressed data as indicated on the ground level recorder is proportional to the radiation level corrected to 3 feet above the surface.

2.1.2 Aircraft to Central Plot Telemeter

The Telepulse telemetering system was developed to transfer the data on the compensated radiation recorder to a central plotting location. The Information Unit, HASL type TF-2-A (Fig. 6a) converts the D.C. reading across the ground radiation level recorder to a pulse train which is fed into the audio input of a standard communications radio transmitter. During Operation Teapot, Motorola 20 watt series L41G transceivers were operated in the 30 to 40 megacycle band. The Central Telepulse station HASL type TT-1-A (Fig. 6b) is fed the pulse train from a radio receiver which is matched to the aircraft transmitter. This pulse train is stripped of noise, shaped, and converted to a D.C. reading and recorded on a graphic recorder.

2.2 GAMMA RAY SPECTROSCOPY

The project called for analyzing gamma ray spectra of shot debris, both from surface samples taken to a laboratory and in the air above contaminated areas. These data may be related by identifying isotopic constituents of samples from various shots and locations and computing the air absorption for each component. The spectra are modified by the absorption of the gamma rays in the air layers between plane and ground levels. The modified spectra should then be measurable by a portable unit.

2.2.1 Laboratory Gamma Spectrometer

A laboratory gamma spectrometer was installed at Camp Mercury to analyze all soil samples at early times so that fresh fission spectra could be obtained. This spectrometer consists of a scintillation detector (Fig. 7) comprising a 3" diameter x 3" long NaI/ThI phosphor coupled to a 3" diameter photomultiplier tube. The output from this type of detector is a series of randomly distributed electrical pulses. Most of the interactions within the crystal are by photoelectric collision wherein there is total gamma energy transfer. Thus the amplitube of each pulse is directly proportional to the energy of the initiating gamma photon. These pulses are amplified, shaped (Linear Amplifier, HASL type TA-2-B), and sorted according to amplitude by a single channel differential discriminator (Atomic Instrument Co., Cambridge, Mass., Model 510). At any specific bias setting of the discriminator, the output pulses are proportional to the number of gamma events with a specific energy. The pulse rate is measured by a count ratemeter (HASL type TM-3-B). The bias setting is automatically swept through all energies from 0.005 Mev to 3 Mev maximum (Discriminator drive, HASL type TC-5-A). The number of gamma photons at each energy is displayed on an Autograph X-Y Recorder (F.L. Mosely Co., Pasadena, Calif.). Spectra from known isotopes such as cobalt-60, and sodium-22 were used for calibration (Fig. 8), and the detector efficiency has been tabulated (Table 1) and plotted (Fig. 9).

Table 1 -- DETECTOR EFFICIENCY

Isotope	Energy	Raw (C/s)	Peak/total	Absorption Calculated	Efficiency
Co-60	1.33 Mev	662	18.4%	70.5%	13%
	1.17 Mev	722	20%	74%	14.8%
		Total 7,200			
Na-22	1.28 Mev	910	(18.9%)*	71.5%	13.1%
	0.51 Mev	5,040	40%	93%	37.2%
		Total 17,400			
Cs-137	0.67 Mev	1,205	29.7%	88	26.1%
		Total 4,060			

*Note: Extrapolated from Co-60 data

Raw C/s is tabulated from basic intensities detected as evaluated from Fig. 8. The peak to total ratio describes the distribution between the photoelectric peak and the total number of photons which interact with the phosphor.

2.2.2 Portable Gamma Spectrometer

A gamma spectrometer for portable operation was developed. Standard equipment which is designed for laboratory use is not suitable for field use because of size and power requirements. The instrument is a novel single-channel, automatic sweep, pulse height analyzer (Fig. 10), operated in conjunction with a scintillation detector which is comprised of a 3" diameter x 3" long sodium iodide, thallium iodide activated crystal and 3" diameter photomultiplier. Because of the wide range of gamma intensities encountered between various altitudes, the instrument was designed to record between 30 and 100,000 events per second with a circuit dead time of 100 millimicroseconds. Thus it is possible to measure spectra in moderately high radiation fields without loss of data or resolution. An X-Y Recorder (Moseley Co., Pasadena, Calif., Autograph) displays the data with the X axis proportional to gamma energy and the Y axis proportional to photons per second. A single sweep of a spectrum may be completed within one minute. Longer sweep times are available to minimize statistical deviations with low activity sources. The unit operates with a 28 volt or 12 volt input and is easily adaptable to 6 volt operation. The power required is approximately 300 watts, so that the unit may be operated in an automobile or helicopter.

2.3 BETA RAY ANALYSIS

Special instruments were developed for field operation, so that the type and intensity of the beta contribution might be studied. These will permit evaluation of the possible distortion in measurements made with conventional instrumentation.

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2.3.1 Beta-Gamma Spectra

Beta flux is not normally measurable in the presence of a gamma field. Some gamma photons will interact with surrounding matter to produce photoelectrons and Compton electrons which are indistinguishable from beta particles.

An instrument was designed to measure beta energies by deflecting the beta particles with a magnetic field. Gammas are a form of electromagnetic radiation and will not be affected. The detector is a scintillation phosphor (sodium iodide, thallium iodide activated crystal, $1\frac{1}{2}$" diameter x 1" high) and a photomultiplier tube, mounted in a heavy shield (Fig. 11) which has a small hole to collimate the incident beta and gamma radiation. The composite spectrum is recorded first, then a magnetic field is applied across the collimator port to deflect the beta particles away from the detector. The gamma spectrum is recorded and by difference one can evaluate the beta spectrum. The output from the magnetic beta scintillation analyzer unit feeds the pulse height analyzer section of the laboratory gamma spectrometer (Section 2.2.1) or that of the portable gamma spectrometer (Section 2.2.2).

2.3.2 Beta Dose Survey Meter

The Beta Dose Survey Meter, HASL type TH-12-A (Fig. 12), is self-contained, self-powered unit used to obtain field measurements of depth dosage per unit time from beta irradiation. The detector is a thin plastic phosphor (5" diameter x 1/8" thick). The light flux produced in the phosphor is proportional to the absorbed energy. A 5" diameter photomultiplier tube converts the light to electrical energy and amplified this signal. The photomultiplier output signal is integrated by an electronic circuit which drives an output meter. A series of lucite filters, with incrementally increasing thicknesses, is inserted in front of the phosphor to reduce the energy of the beta components stepwise until all the energy of the beta particles is absorbed. The residual reading is the gamma dose rate. The reading with any specific thickness of absorber is equal to the dose at a depth which corresponds to the equivalent filtration of intervening tissue.

The completed unit has four linear scales of decreasing sensitivity:

Scale A - X 1
Scale B - X 3
Scale C - X 10
Scale D - X 30

Full scale deflection on Scale D corresponds to 60 mr/hr gamma radiation. A beta calibration for uranium indicates that the full scale reading (Scale D) corresponds to 195 mrep/hr.

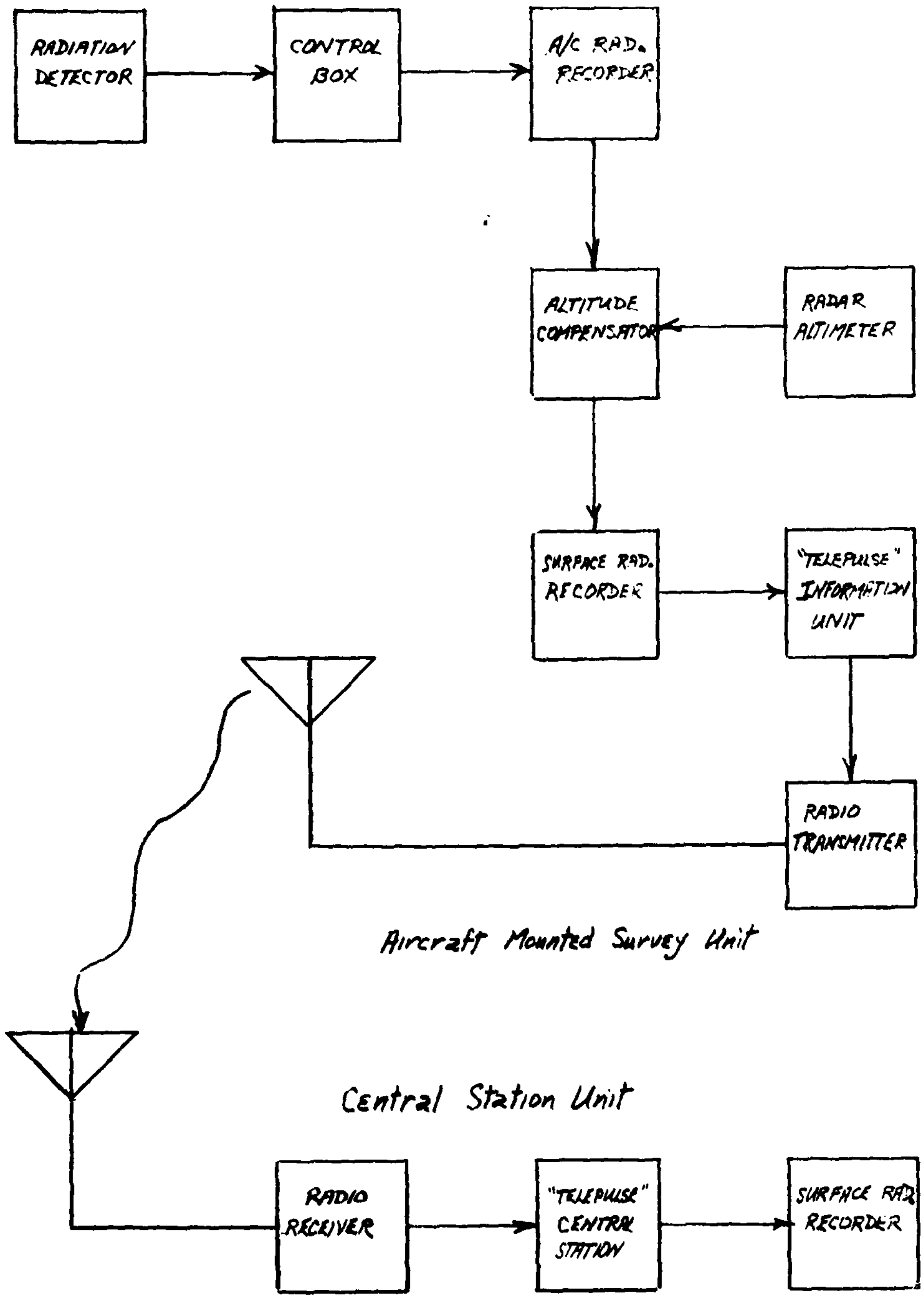

Fig. 1 Block diagram of aerial survey system.

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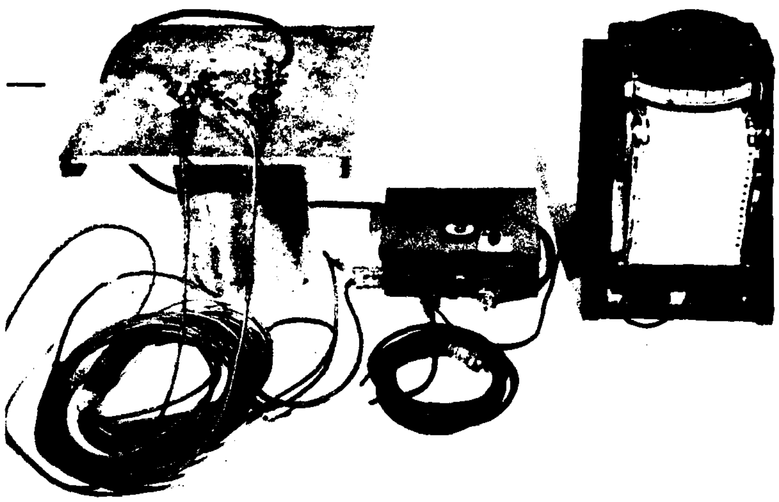

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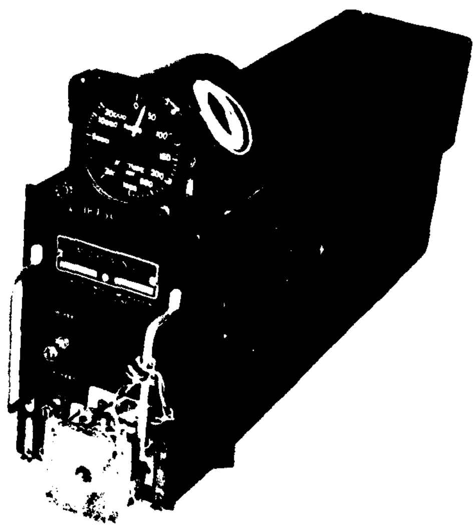

(b)

Fig. 2 (a) Radiation detector unit. (b) Radio altimeter altitude compensator of aerial surveying system.

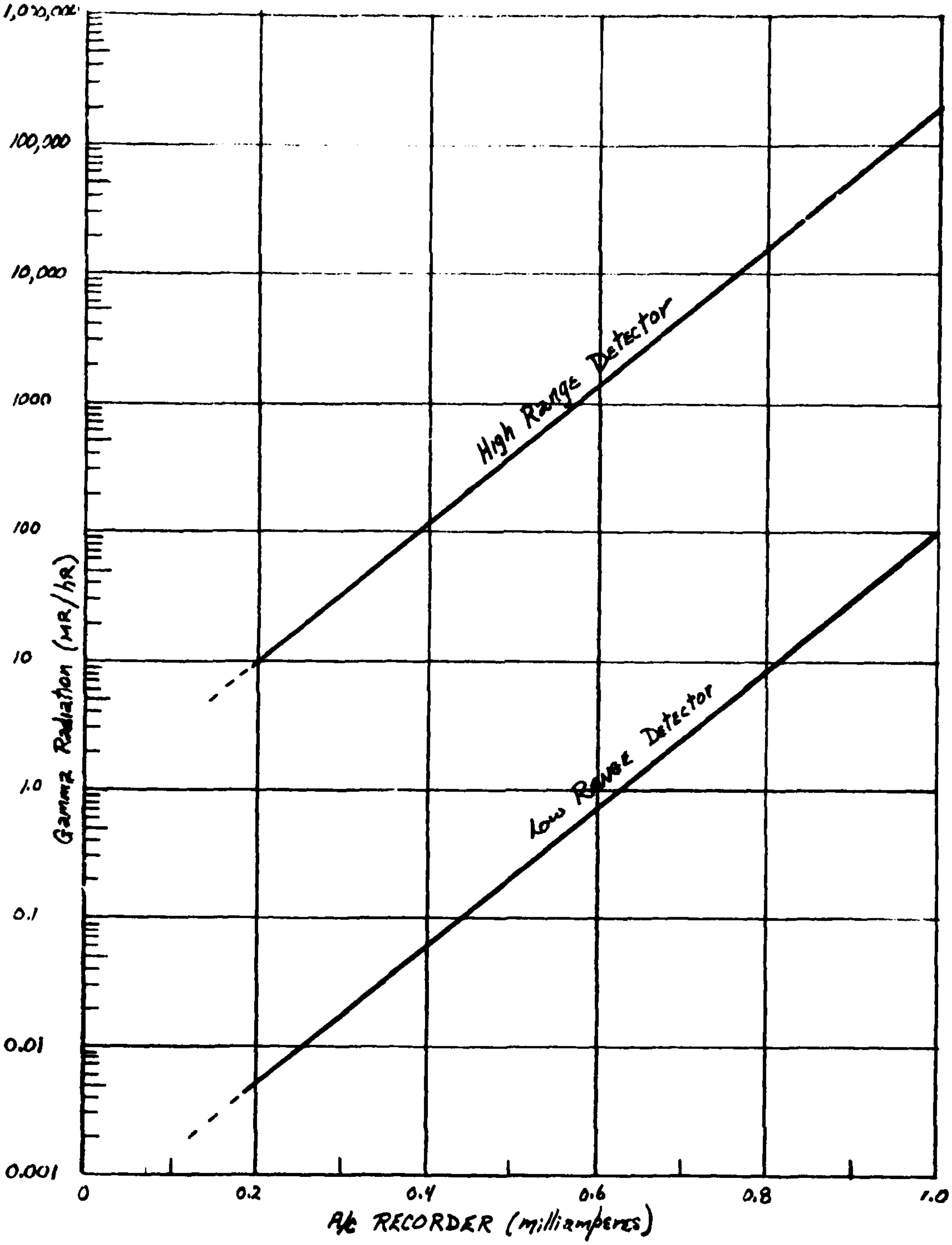

Fig. 3 Detector calibration.

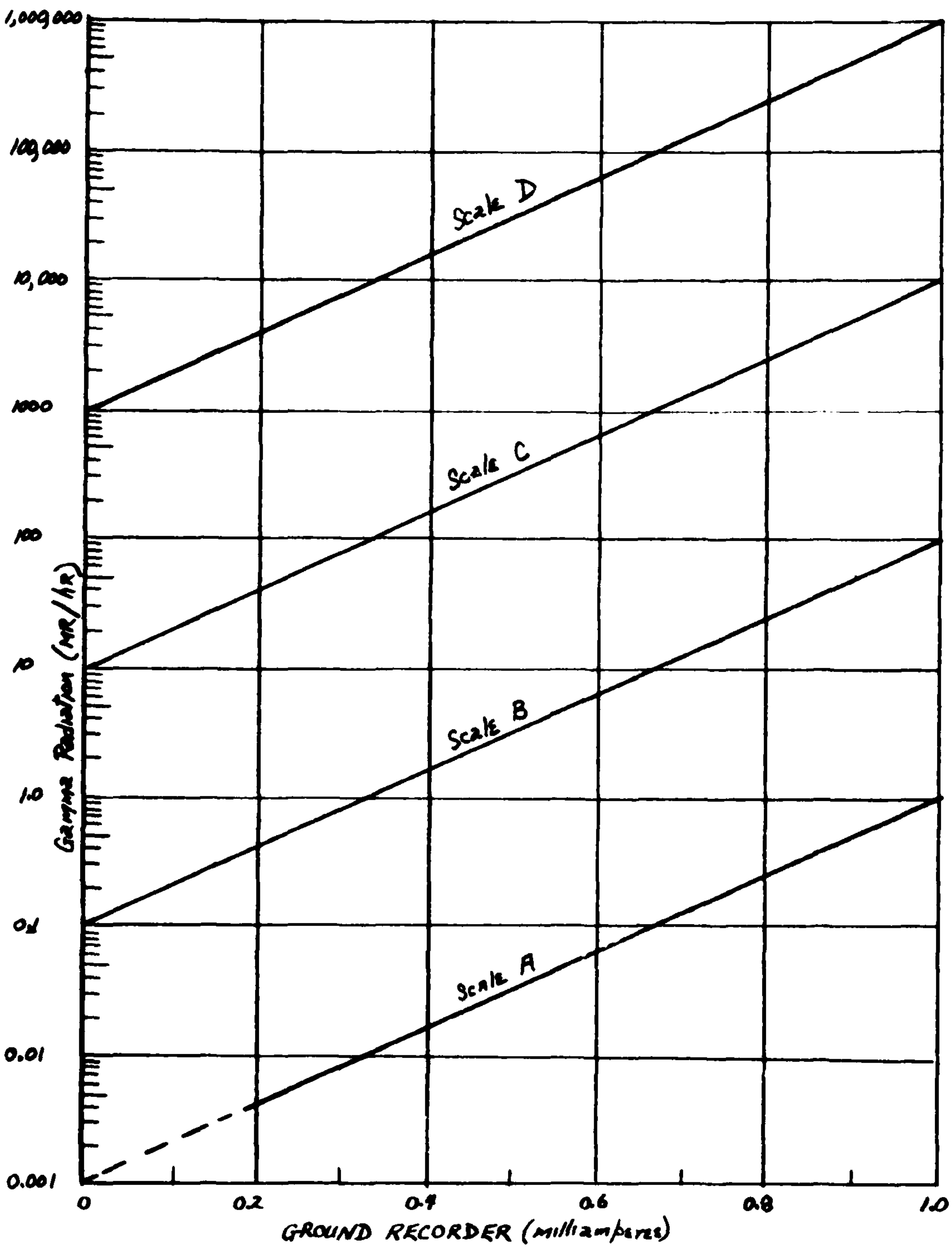

Fig. 4 Survey unit calibration.

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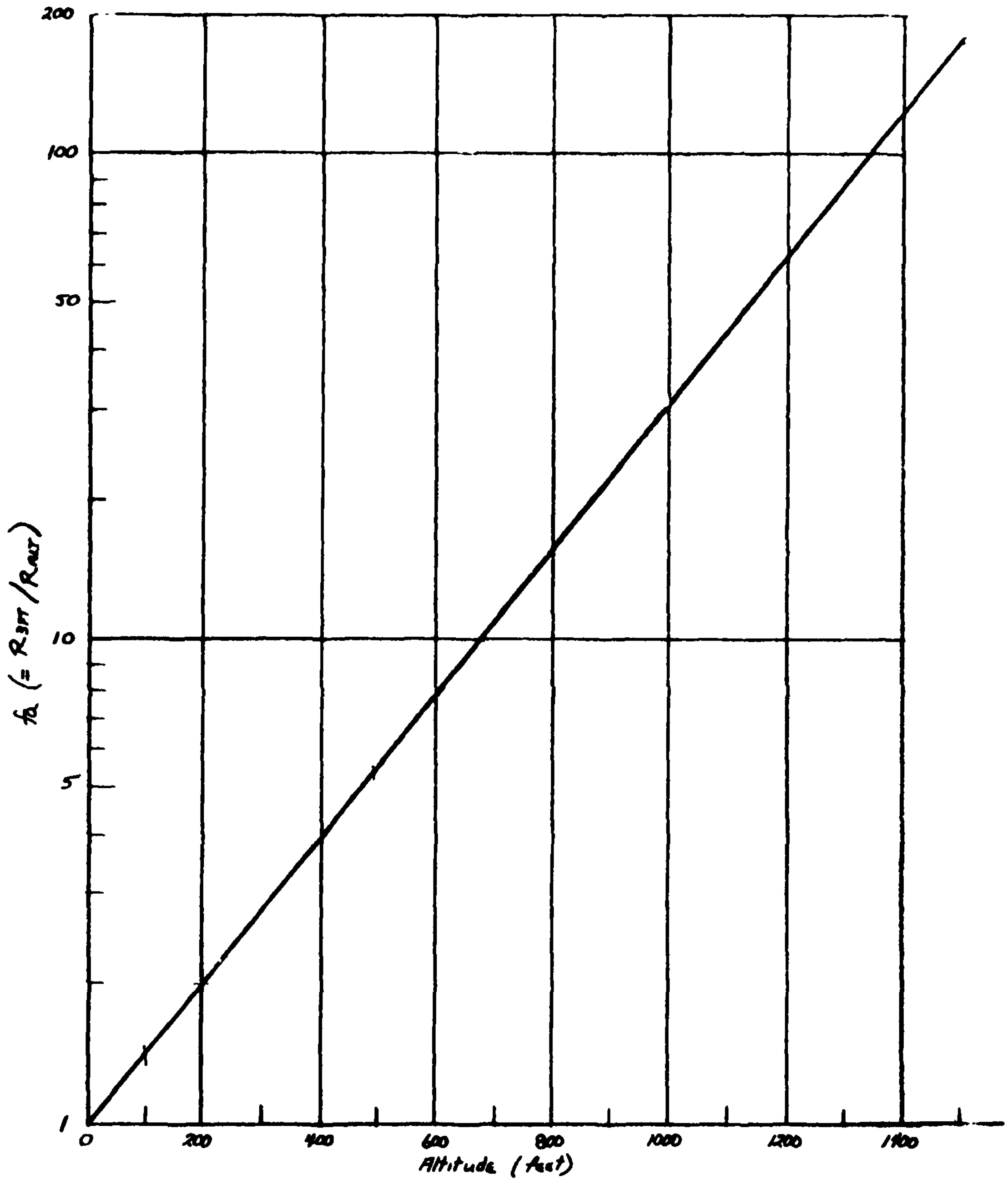

Fig. 5 Altitude compensation factors.

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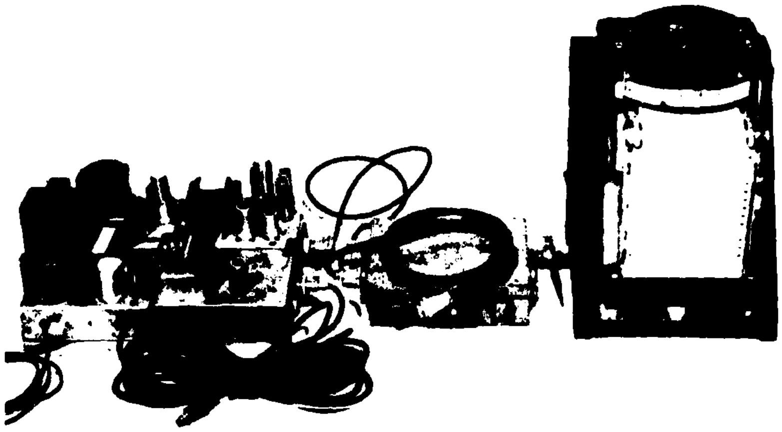

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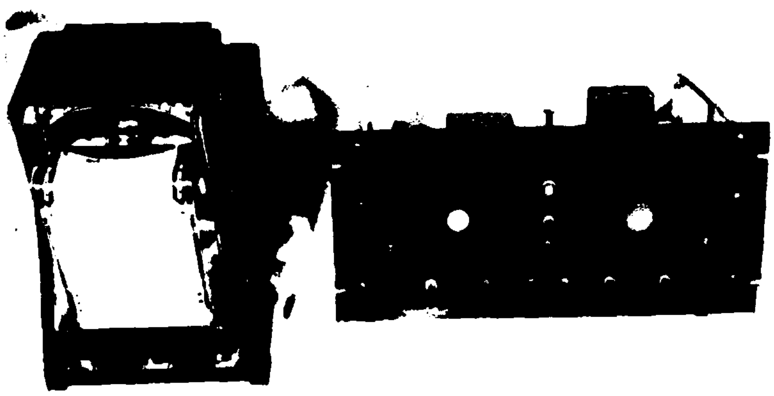

(b)

Fig. 6 (a) Telepulse remote information unit with radio junction box.
(b) Telepulse central station aerial telemetering equipment.

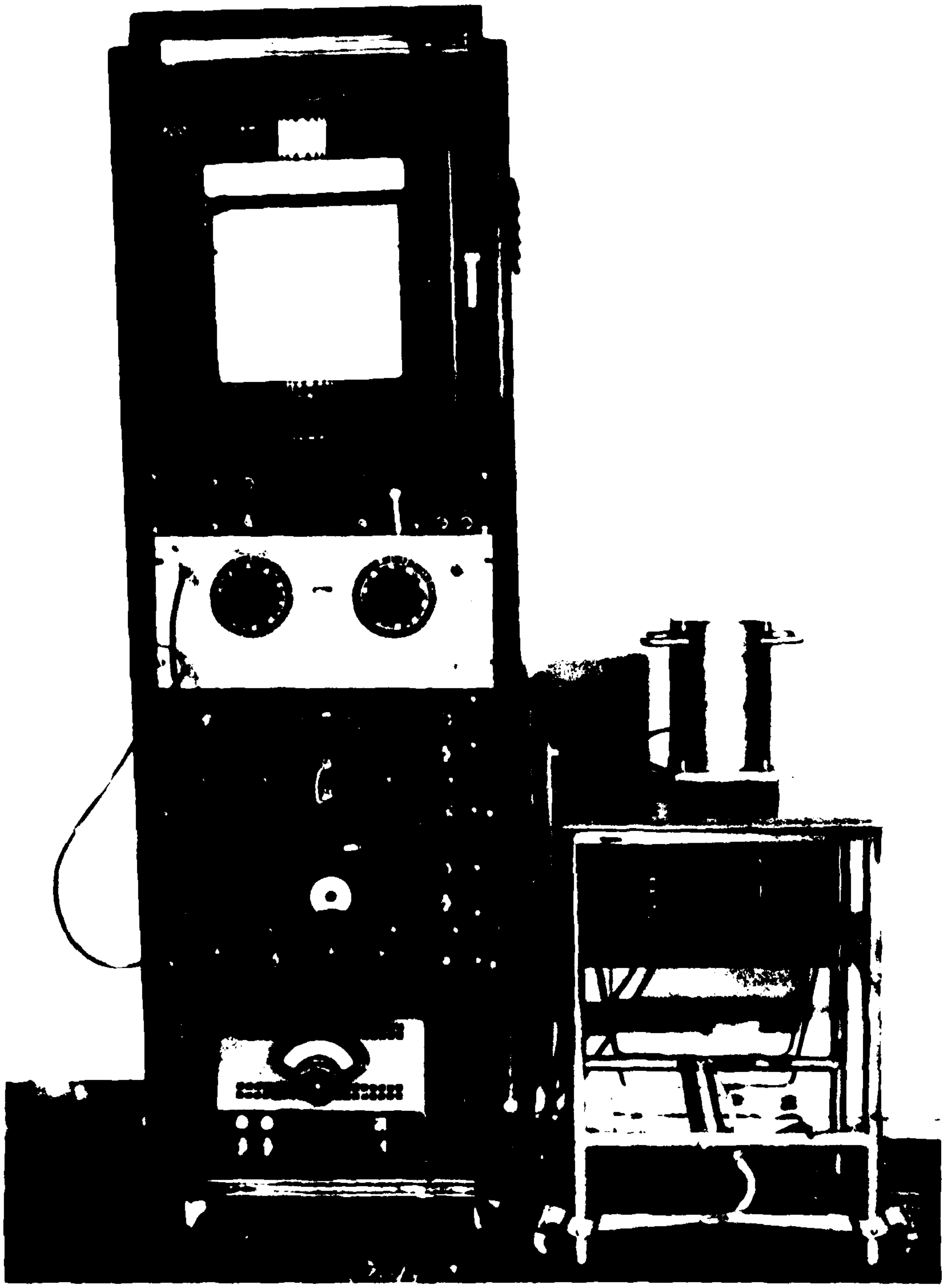

Fig. 7 Laboratory gamma spectrum analyzer.

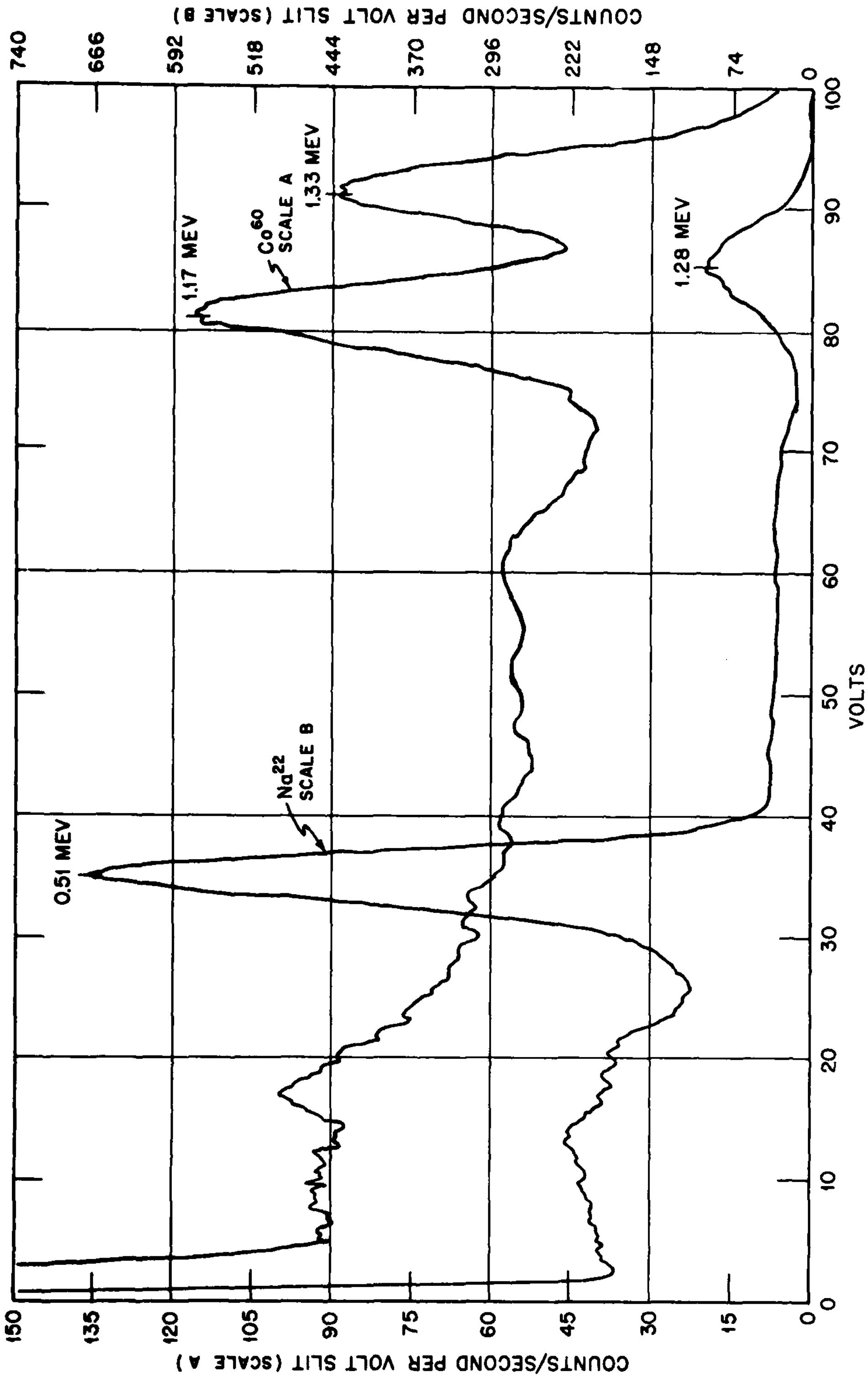

Fig. 8 Calibration curves for spectrum analyzer.

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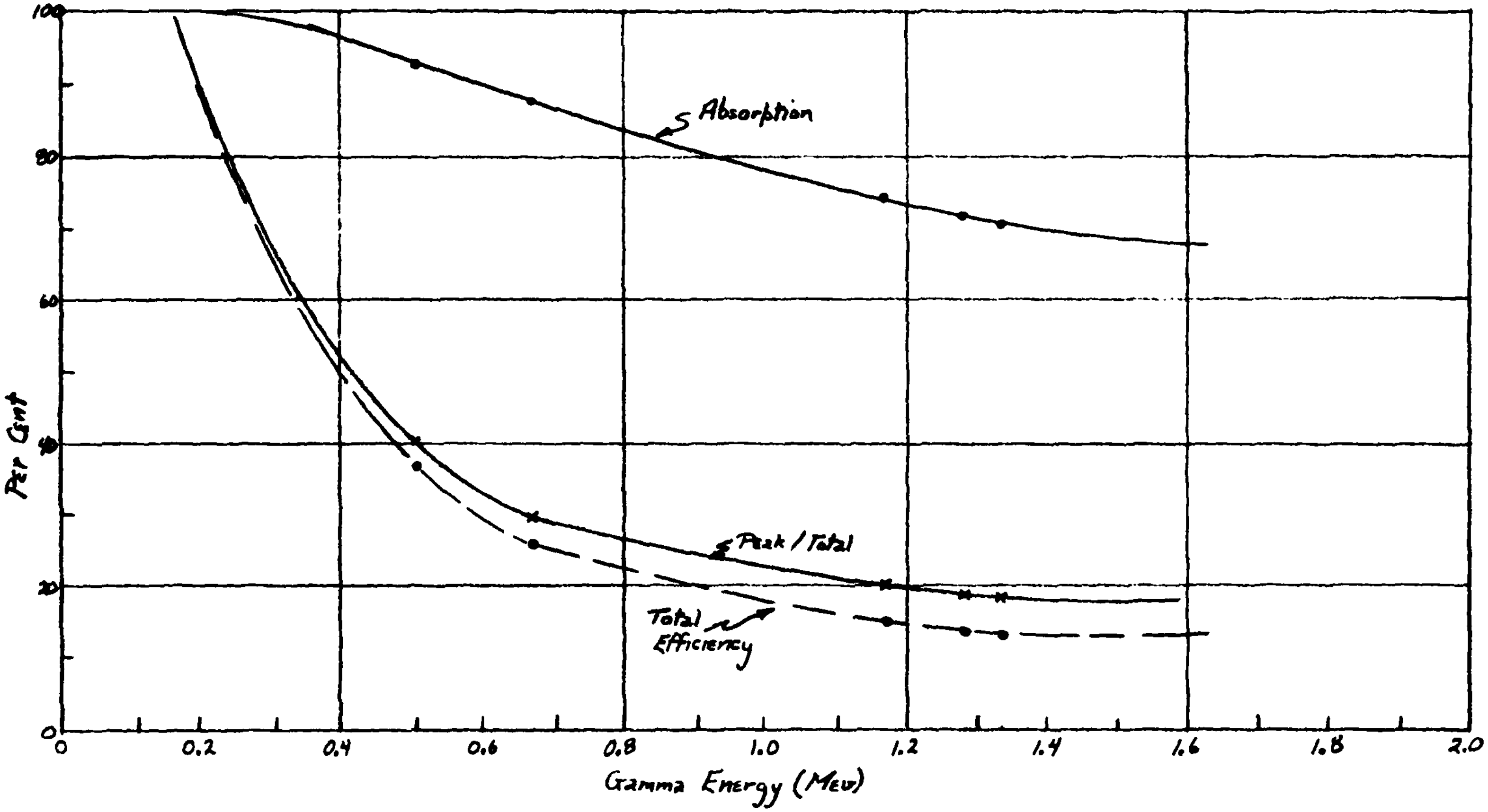

Fig. 9 Detector efficiency of spectrum analyzer.

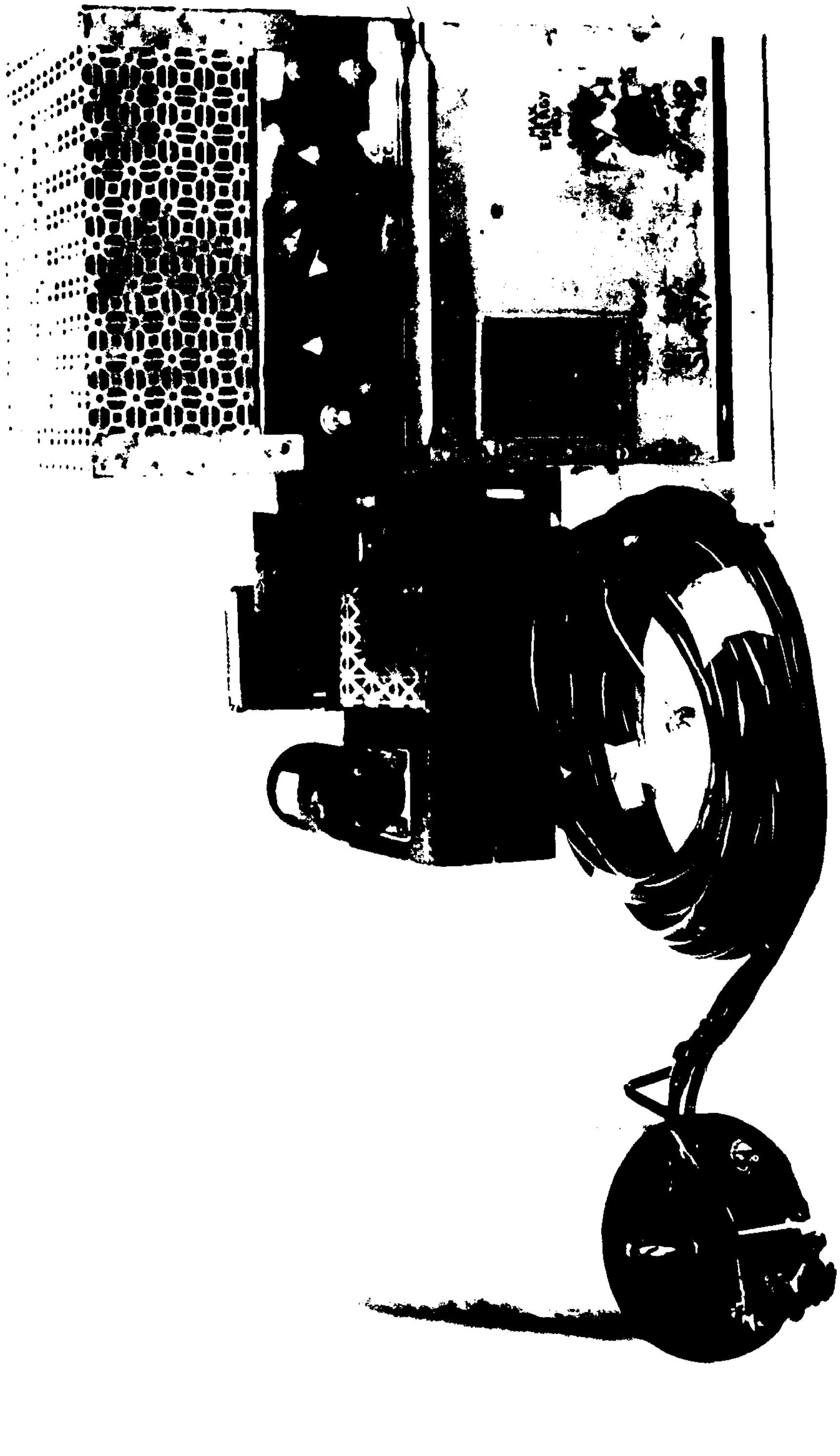

Fig. 10 Portable gamma ray spectrometer.

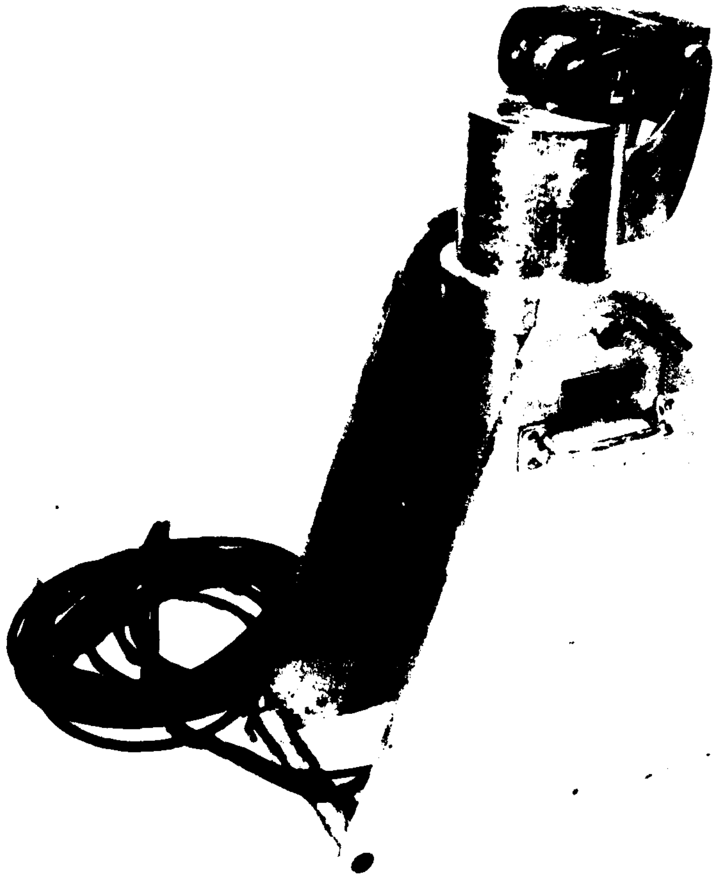

Fig. 11 Magnetic shifter for beta spectral analysis.

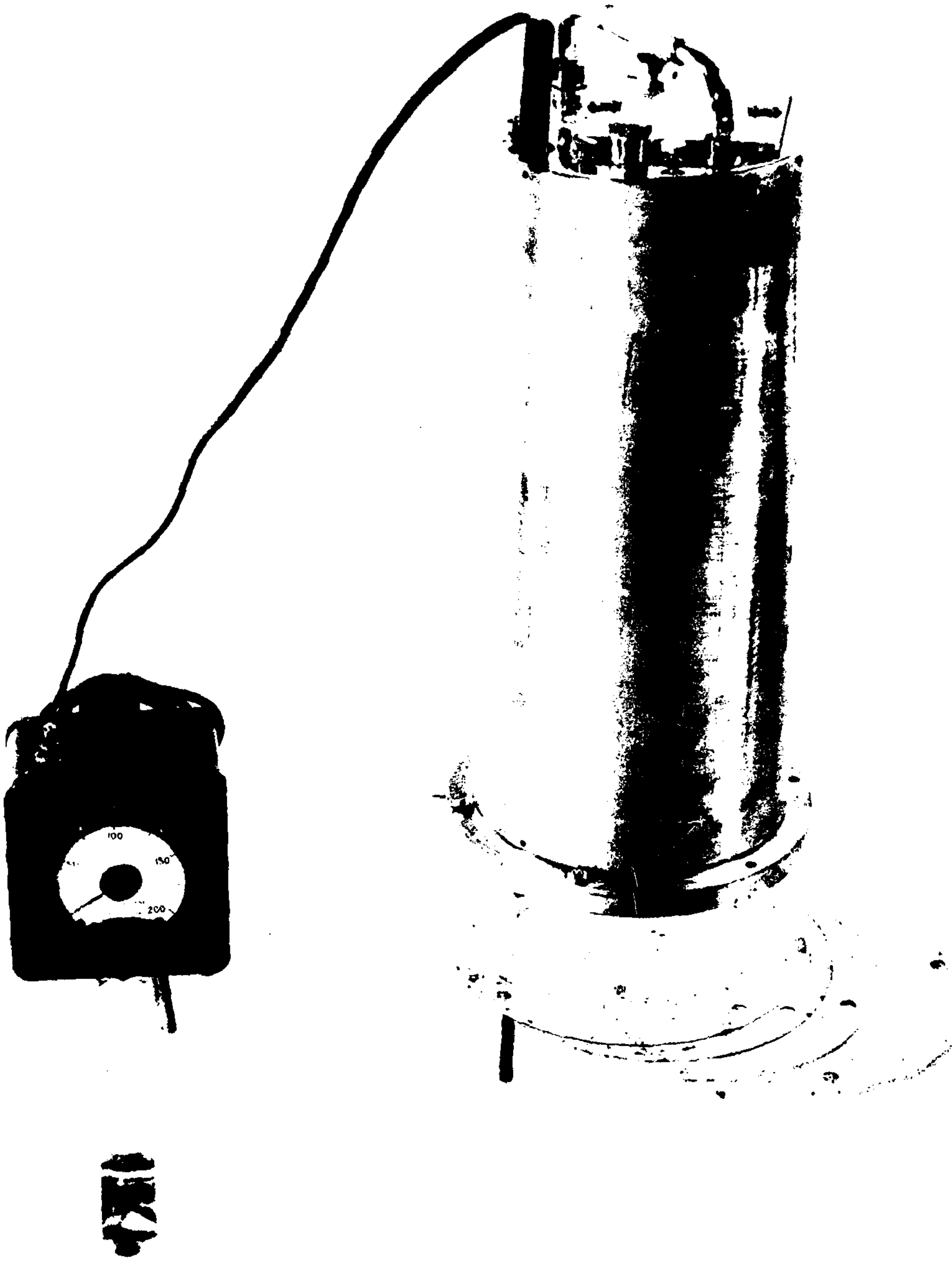

Fig. 12 Beta dose survey meter.

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CHAPTER 3

DATA EVALUATION

3.1 GENERAL REMARKS

The Project 30.3 had two major objectives: development of instruments and techniques, and compilation of radiation characteristics of fall-out from the shot debris.

The development of the instruments discussed in Chapter 2--aerial survey, gamma spectrometer and beta survey units--was completed and field tests were performed at the Nevada Test Site during the Teapot series. Results of the instrument tests and the evaluation of the specific sets of data are discussed in detail in Sections 3.2 through 3.4.

3.2 AERIAL SURVEY

3.2.1 Equipment

The aerial survey unit was flown at the Test Site in such a pattern that it would pass over a large number of "used" shot sites (Fig. 13). Data on instrument response and telemeter accuracy were secured; specific radiation profiles relating to individual shots were not required. The flight record shown in Fig. 14 is typical of the results.

3.2.2 Altitude Factor

For areas contaminated by fall-out, absorption of gamma radiation by the layers of air between the ground and aircraft had been studied by taking a large number of observations during Operations Ranger, Ivy, Upshot-Knothole, and the Castle series. During Teapot, helicopter missions were flown at approximately F+2 hours to confirm and expand these data at early times.

Tesla and Hornet were low yield shots which were fired from relatively high towers. As a result, the onsite contamination was limited to the immediate vicinity of the tower. During the Tesla mission, the contribution of the radiation from the Ground Zero area was much greater than the radiation from contamination at approximately a mile from Ground Zero. Since the slant distances from the helicopter to GZ remained almost constant, there was practically no change in radiation reading as the altitude increased (Fig. 15).

[redacted]

For the Hornet mission, the detector was collimated to eliminate the side radiation contribution (Fig. 16). Because of the character of the contamination pattern, the data seem to fall off in approximate accordance with an inverse square law (Fig. 15). It is not proportional to the air absorption law that would be expected from an infinite plane source. However two additional passes were made over ground zero:

500 feet	45 r/hr
1000 feet	9 r/hr

These two points fit a curve (Fig. 15) based on air absorption over an infinite source. Thus, while the contaminated pattern in the region of the detailed survey must have been sharply limited and approximated a point source, the contamination in the region of GZ was distributed widely enough to approximate an infinite plane.

The data from the Turk mission, Fig. 17, correlate with a curve based on air absorption over an infinitely broad source. Both runs read high at ground level, which could be contributed by the beta radiation. The discrepancy above 300 feet for Run #1, and 600 feet for Run #2 is in agreement with the added contribution from surface zero similar to the results obtained on the Tesla mission. However, Turk was a much higher yield shot and the material was distributed over wider areas. Thus the deviation, which depends on this distribution and the terrain, is less pronounced.

3.3 GAMMA RAY SPECTRA

3.3.1 Soil Samples

Soil samples were collected after eight shots; part was retained at Camp Mercury and the remainder shipped to HASL, AEC, New York (Table 2). The analytical results from the New York samples were for inclusion in a HASL program and will be reported elsewhere as a part of that work. The samples retained at NTS were analyzed on a gamma ray spectrometer (Section 2.2.1). Figures 18 through 21 are representative curves.

Figure 18 illustrates the gamma spectra resulting from the sodium-24 produced by neutron irradiation. The normal soil sample, F#2, shows very high energy gamma rays (2.7 and 1.4 Mev) resulting from sodium-24 produced by neutron irradiation of normal sodium in the soil. In addition, gamma rays (2.1, 1.8 and 0.85 Mev) were identified from manganese-56 resulting from the neutron irradiation of the tower iron. One sample was separated, however, and a speck found which contained no sodium. Its spectrum shows only low energy gamma rays which are identified as being from fission debris.

Three Tesla samples were analyzed (Fig. 19), and illustrate that the radiosodium component is a function of the proximity to ground zero. F#3 close-in, F#2 from a moderate distance, and F#4 from an offsite sample show progressively less radiosodium. Thus, it appears that the local soil was not picked up by the detonation in appreciable quantities.

Table 2--SOIL SAMPLES

Event	Date, Time (PST)	Sample	Area Rad.	Area Location
Wasp	2/18:1200	-		- - -
Moth	2/22:0545	1	5 r/hr	- - -
Tesla	3/01:0530	1	1/2 mr/hr	- - -
		2	8 mr/hr	- - -
		3	7 r/hr	- - -
		4	20 mr/hr	098° at 65 miles
Turk	3/07:0520	1	45 mr/hr	270° at 1/2 mile
		2	4 mr/hr	300° at 2 miles
		3	5 mr/hr	- - -
Hornet	3/12:0520	1	25 mr/hr	- - -
		2	10 r/hr	180° at 700 ft.
		3	25 mr/hr	- - -
Bee	3/22:0505	1	140 mr/hr	180° at 500 yds.
		2	10 r/hr	180° at 1200 yds.
Ess	3/23:1230	1	10 r/hr	280° at 700 ft.
		2	1 r/hr	280° at 3000 ft.
Apple	3/29:0455	1	- - -	Onsite
		2	- - -	066° at 63 miles
		3	- - -	060° at 105 miles
		4	- - -	060° at 103 miles
		5	- - -	070° at 190 miles
Wasp Prime	3/29:1030	-		
HA		-		
Post	4/09:0430	0	Mercury background analysis	
Met	4/15:1115	1	2 mr/hr	060° at 203 miles
		2	5 mr/hr	080° at 135 miles
		3	15 mr/hr	080° at 135 miles
Apple II	5/05:0510	-	- - -	- - -
Zucchini	5/15:0500	-	- - -	- - -

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Figure 20 presents the gamma ray spectra of a Turk soil sample. While this sample was recovered from an area having a high gamma intensity, it contains a much smaller percentage of sodium-24. As a result of the higher yield of this shot relative to the previously discussed shots, the fall-out was heavier and more widely distributed around ground zero. The sample came from an area where the gamma intensity resulted primarily from the fall-out and only traces were due to the neutron irradiation produced components.

At this time, it appears that the effective gamma energy in a fall-out-produced radiation field is approximately 350 kev. Also, the effective value of these spectra vary as a factor of time and distance from Ground Zero.

A film packet, used by Project 39.1, was appreciably radioactive after exposure close to a shot. From gamma analysis silver-108, bromine-82, and iodine-131 were identified as the isotopes responsible for the gamma radioactivity from the film. In addition, the lead-tin packet showed traces of antimony-128 produced by the neutron irradiation.

3.3.2 Aerial Spectral Analysis

The portable spectrometer (Section 2.2.2) was mounted in a helicopter and flown over the Met area several days after D-day. The gamma spectra obtained at 200 and 400 feet indicate some energy degradation (Fig. 21). This degradation increases with altitude. One is led to consider after referring to the large variations in source constituents (Section 3.3.1) that an altitude correction factor may vary somewhat with the fall-out constituents. However, the mass absorption coefficient for air does not vary widely over a large range of gamma energies. Thus it is possible that the altitude correction factor is less sensitive to variations within the source constituents that might be inferred from the soil sample gamma spectra.

It was not possible to obtain a more complete set of data since the helicopter vibration interfered with the recorder's operation.

3.4 BETA RAY ANALYSIS

The soil sample recovery teams used the beta dose rate survey meter (Section 2.3.2) to obtain beta absorption measurements in the field after Turk and Hornet. The main beta contributions to the curves were based on an end point extrapolation. Analysis of the absorption curves, Fig. 22 and 23, indicate that the results depended upon the shot and/or location of the measurement point. These data were obtained at approximately H+3 hours.

The correlation is good; however, the Hornet data show an additional beta component of 2.2 Mev. The gamma contribution to the Hornet data is high relative to Turk because of the long range contribution resulting from the sharp gamma distribution gradients. This agrees with the effects noted in the altitude absorption data (Section 3.2). The comparison of beta-gamma ratios in Fig. 24 shows the effect of the contribution of the gamma field external to the measurement point. However, the distribution of beta with depth is similar, since the percentage contribution of the Hornet high energy beta is small.

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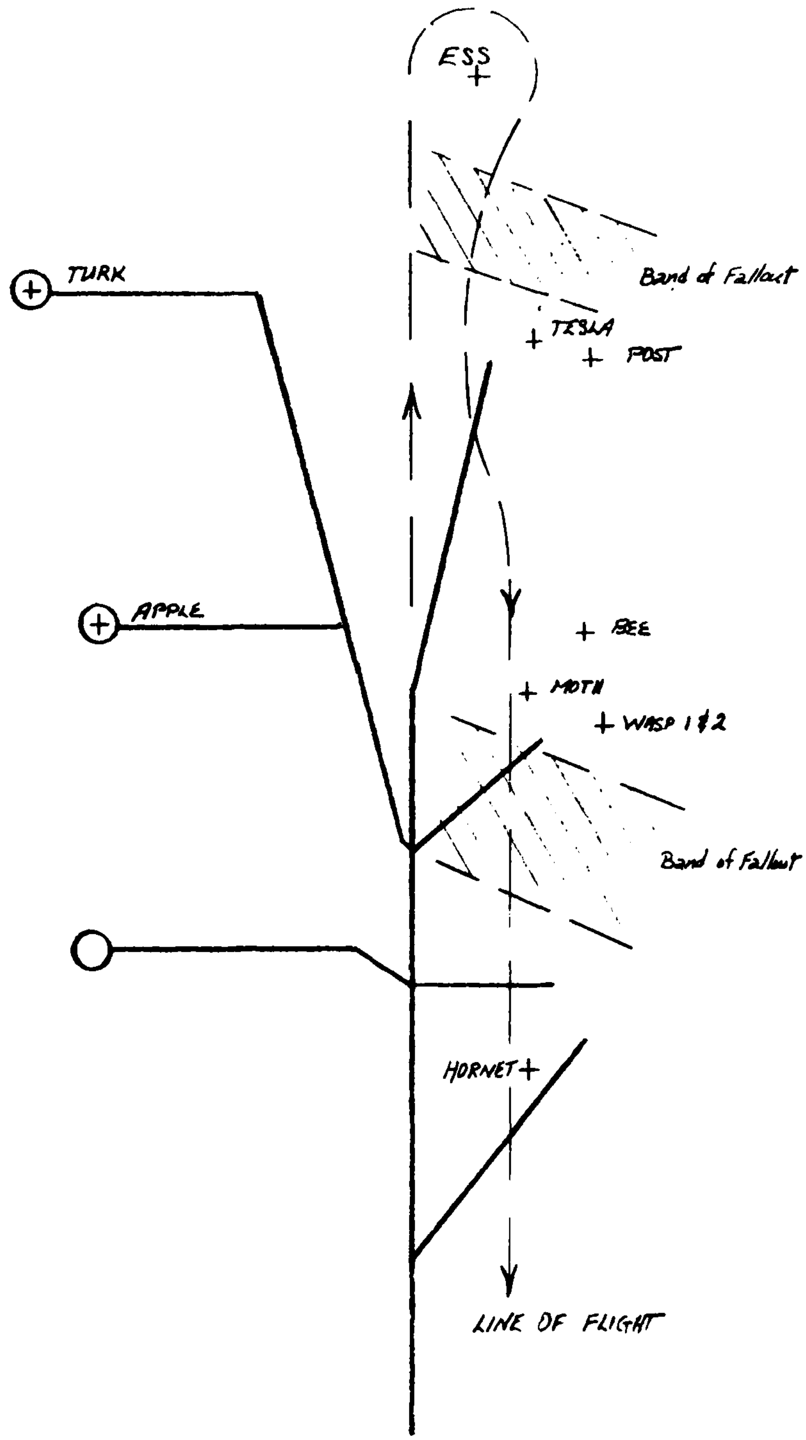

Fig. 13 Flight pattern for aerial survey unit.

[redacted]

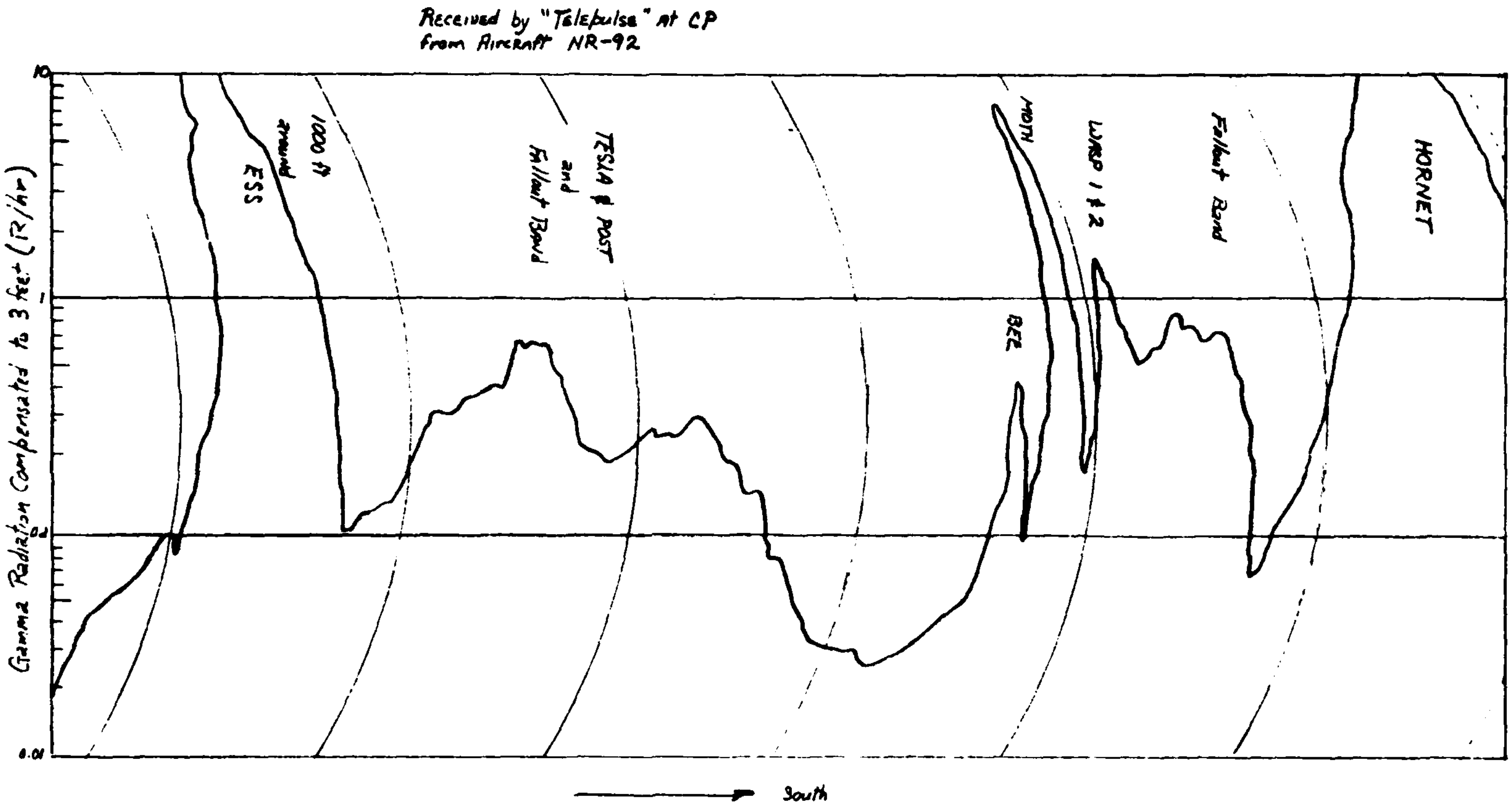

Fig. 14 Typical profile for aerial survey.

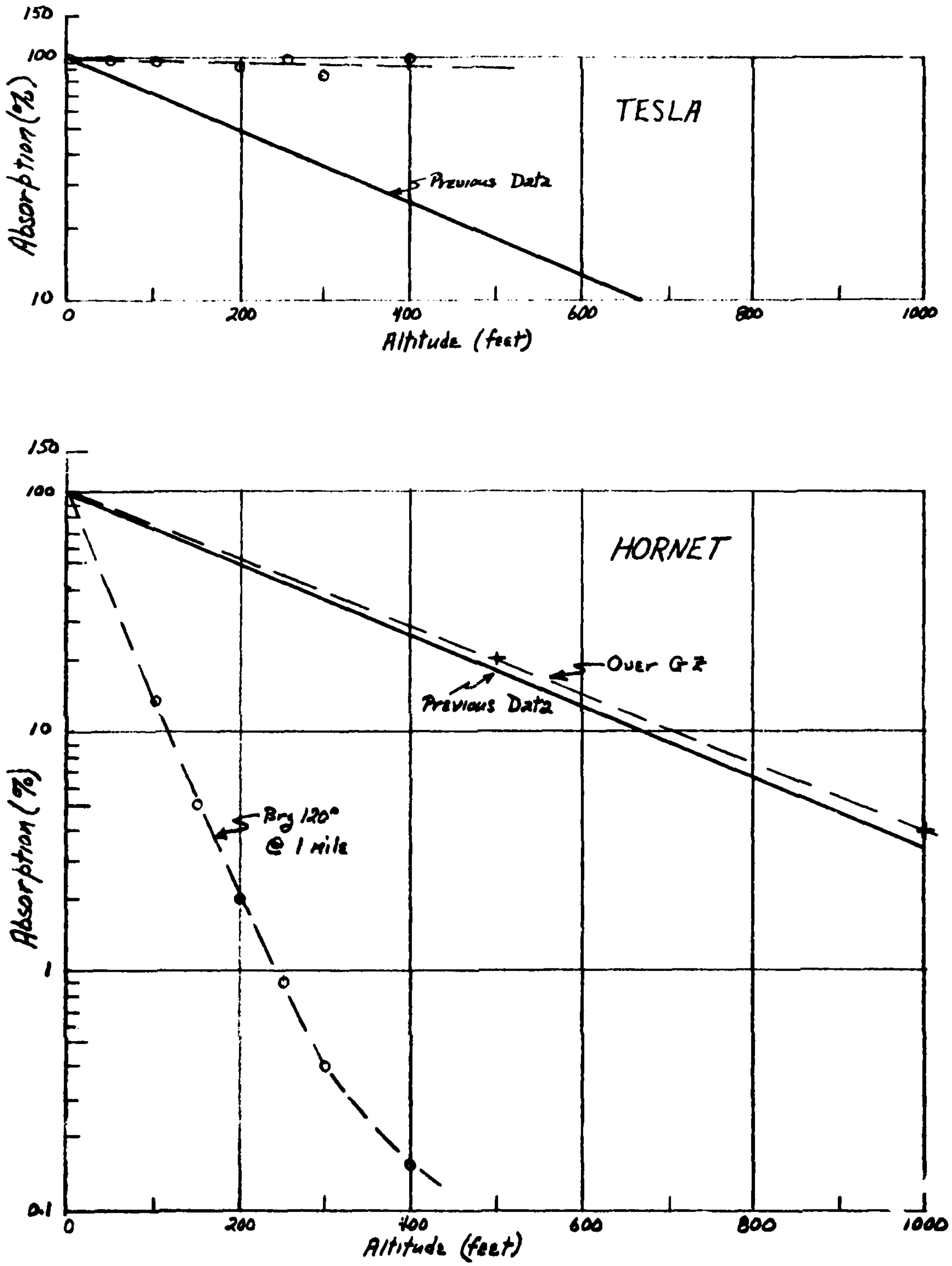

Fig. 15 Air absorption for Tesla and Hornet shots.

[redacted]

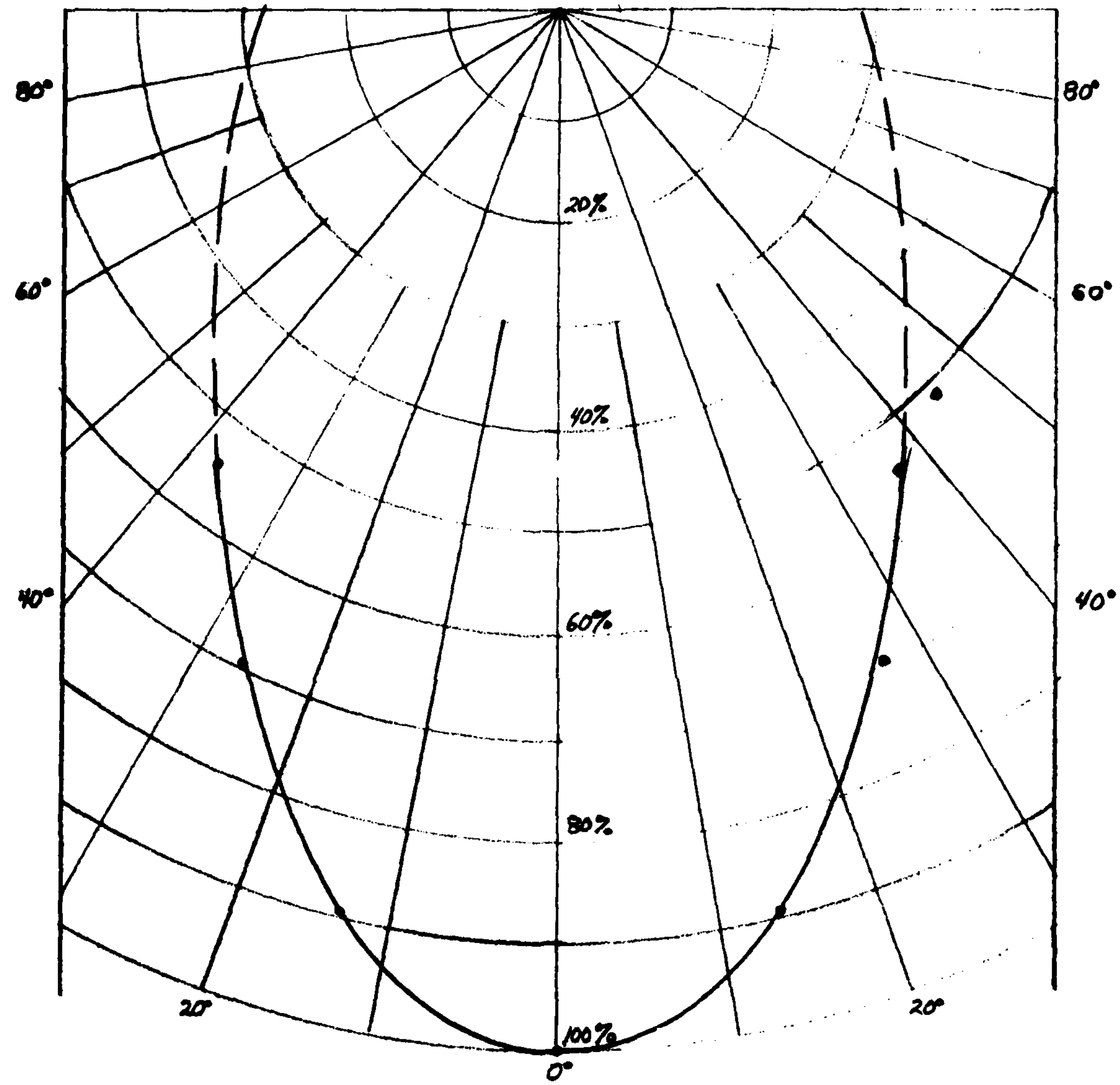

Fig. 16 Angular response of aerial detector.

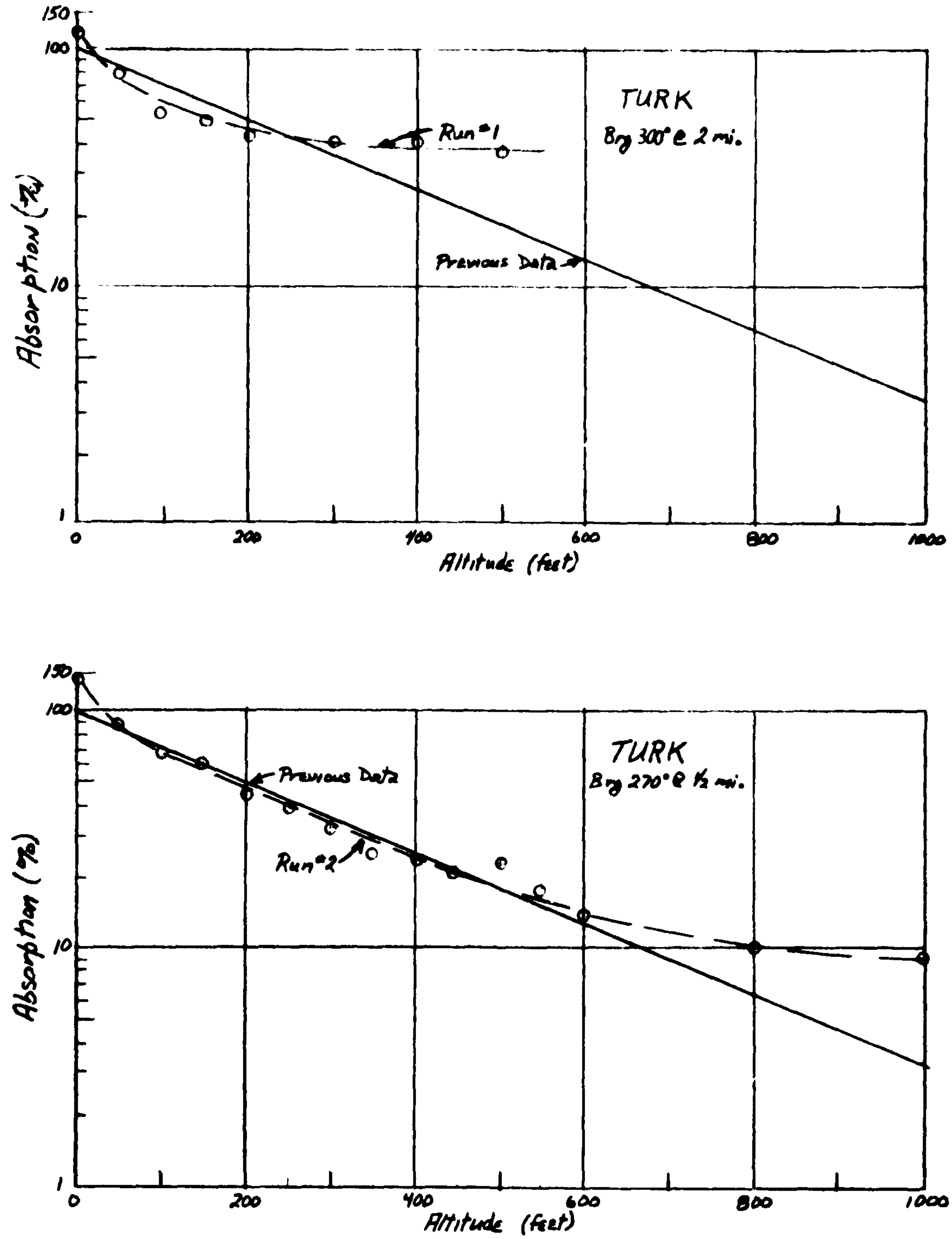

Fig. 17 Air absorption for Turk shot.

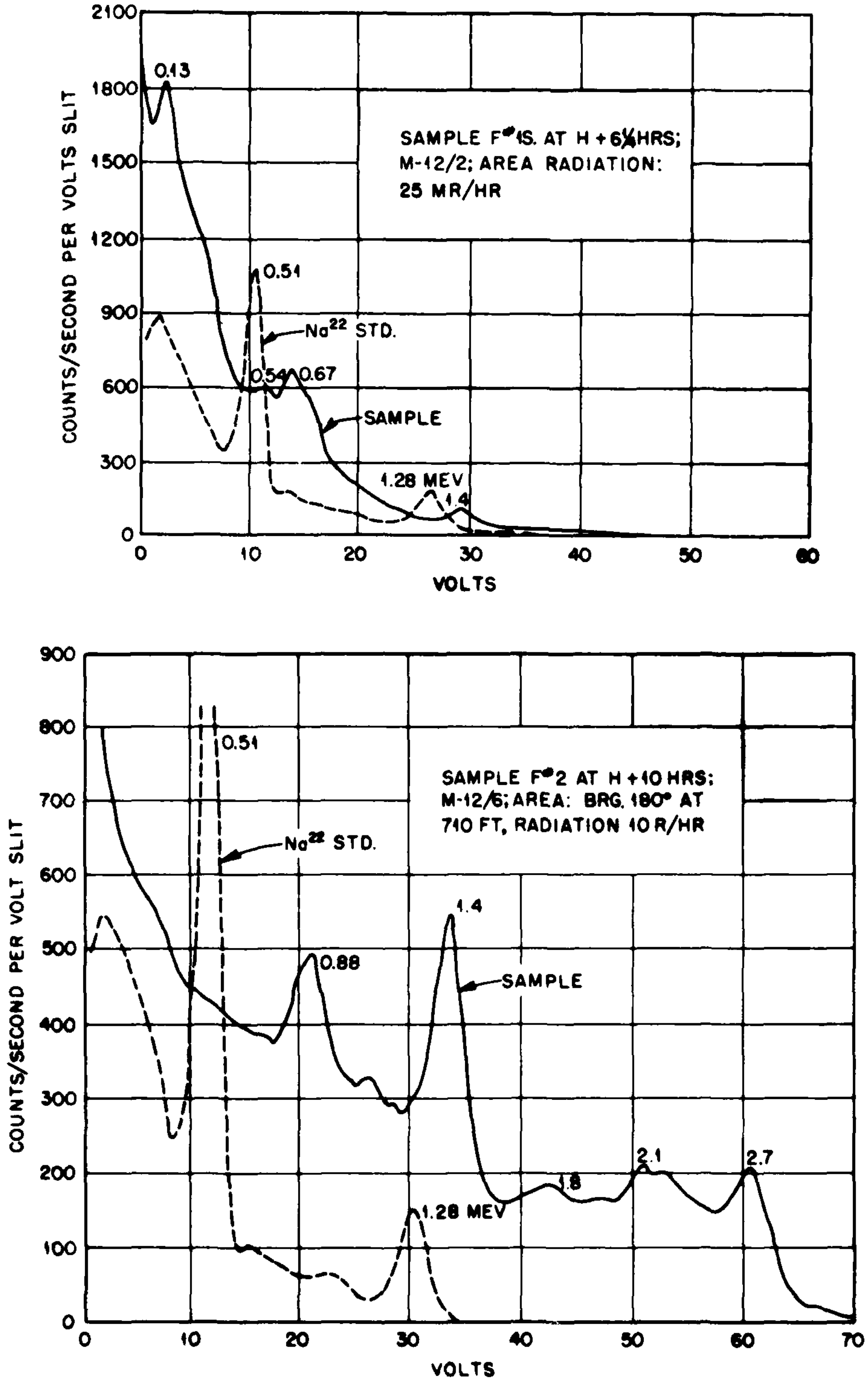

Fig. 18 Soil sample spectra from Hornet shot.

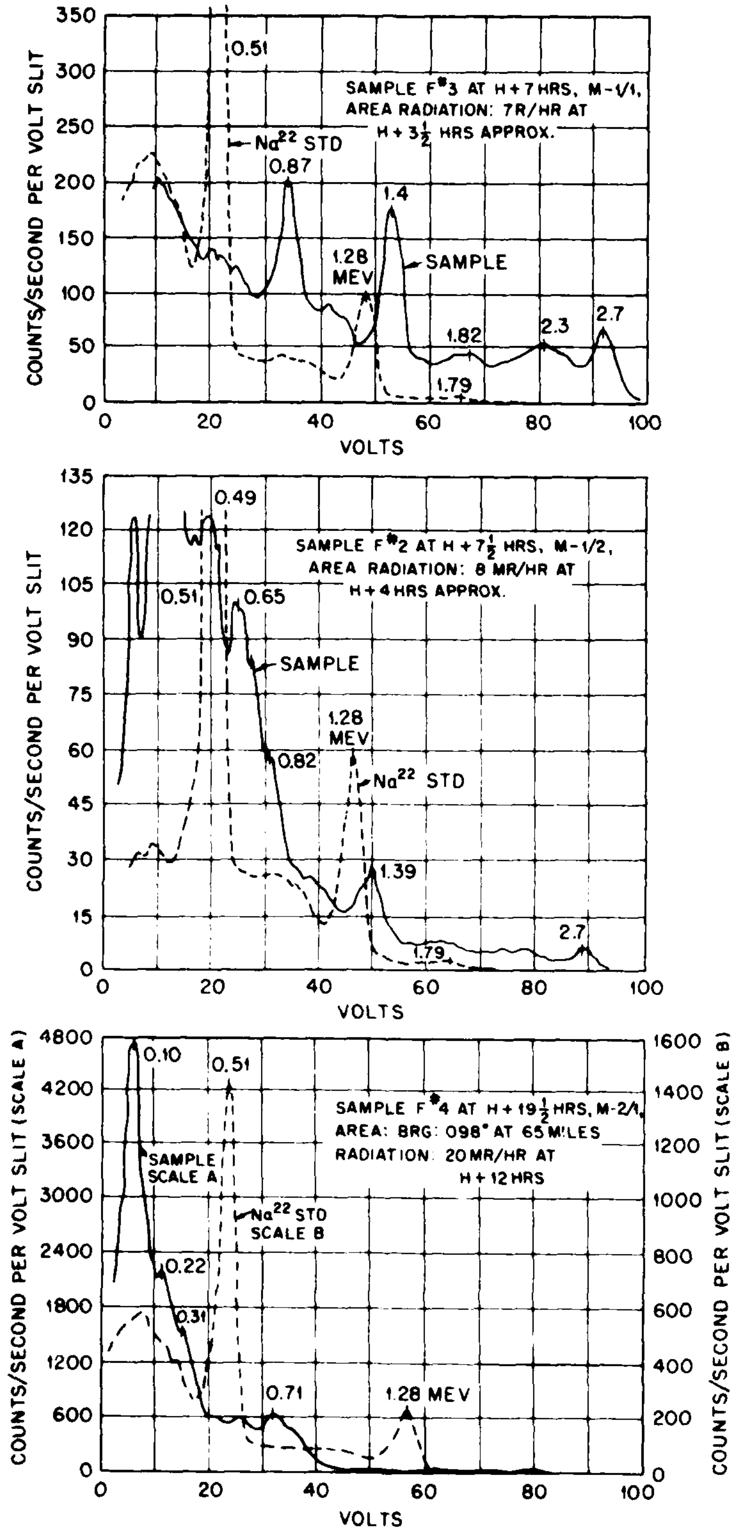

Fig. 19 Soil sample spectra from Tesla shot.

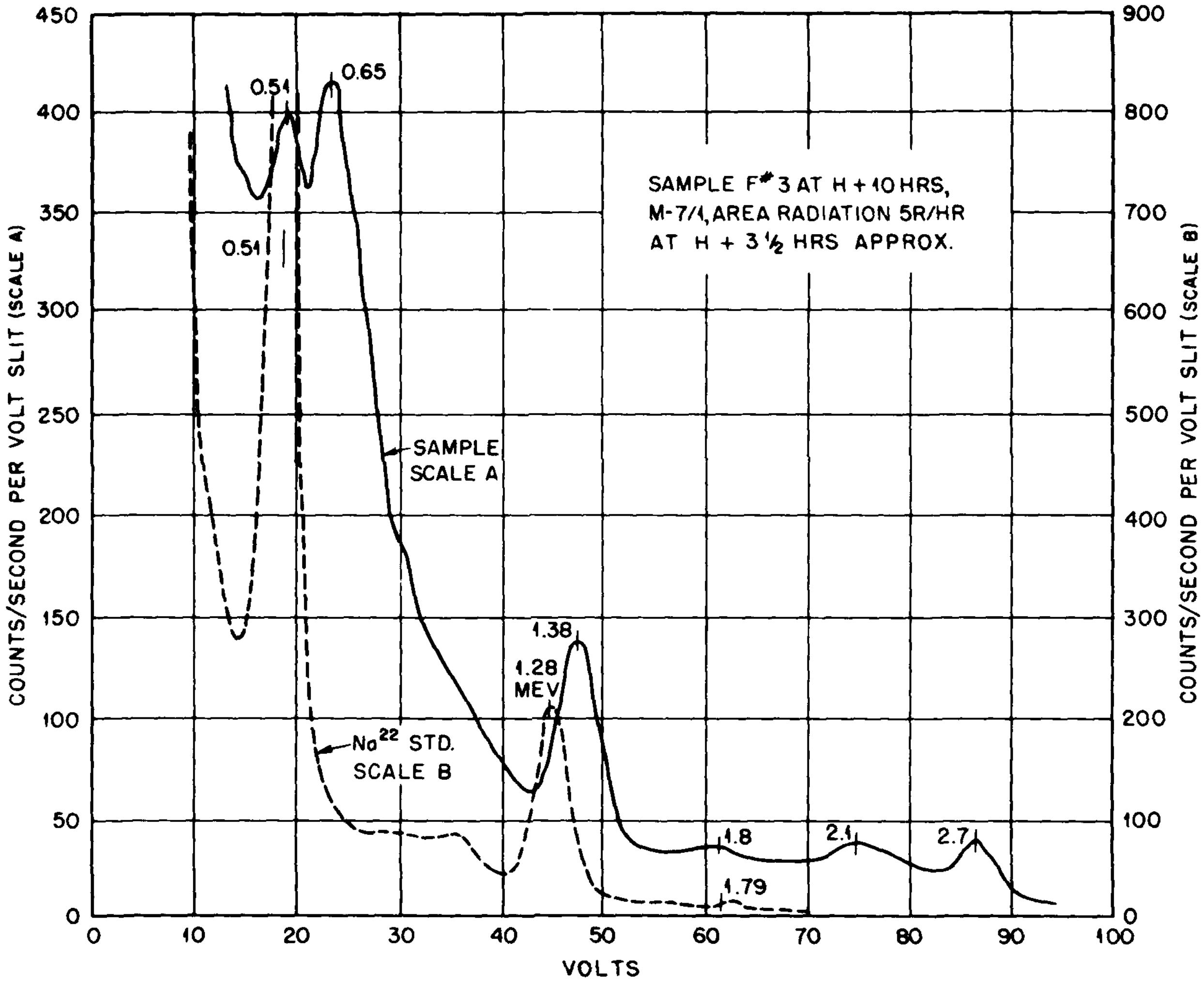

Fig. 20 Soil sample spectra from Turk shot.

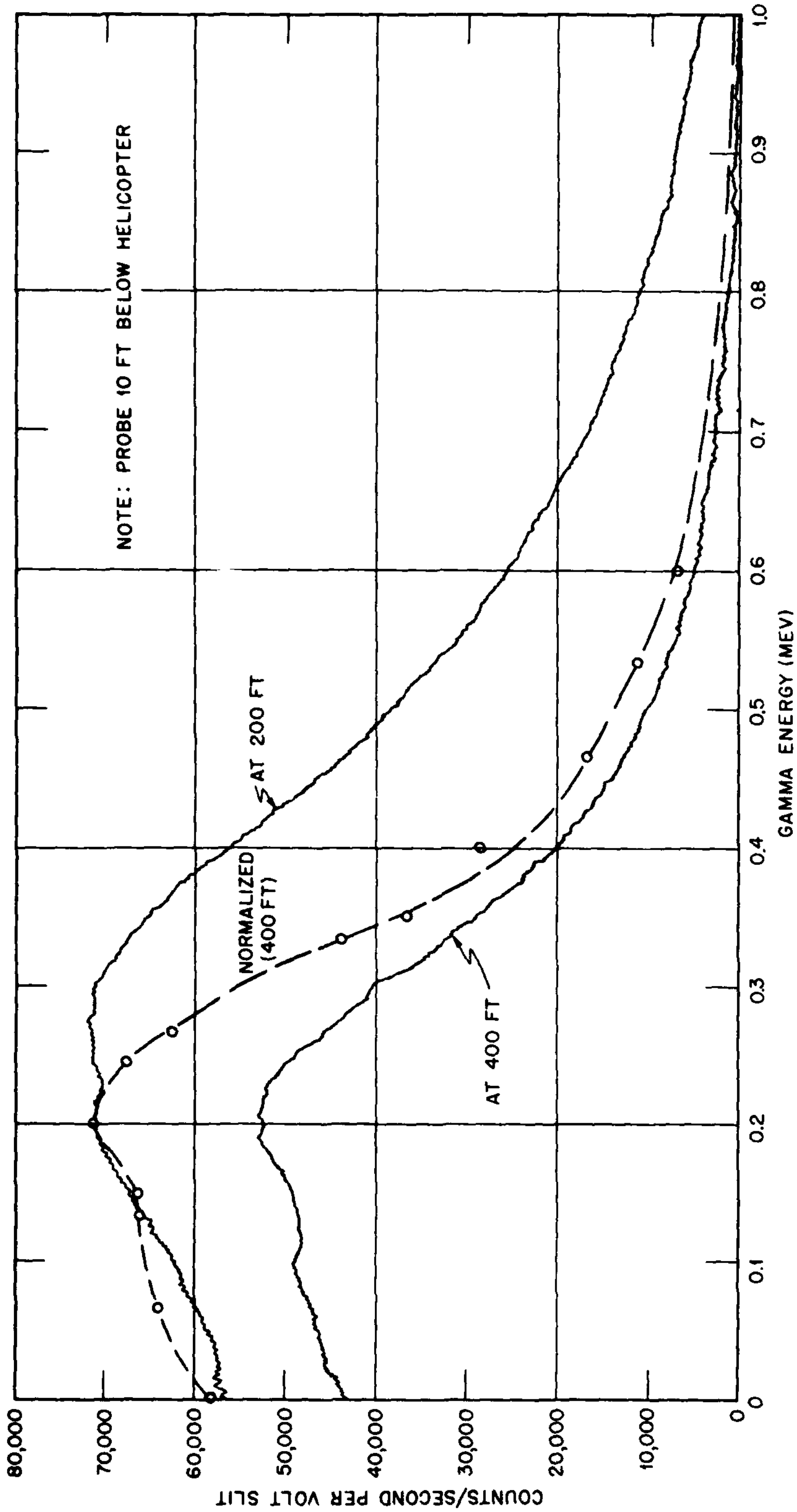

Fig. 21 Soil sample spectra from Met area.

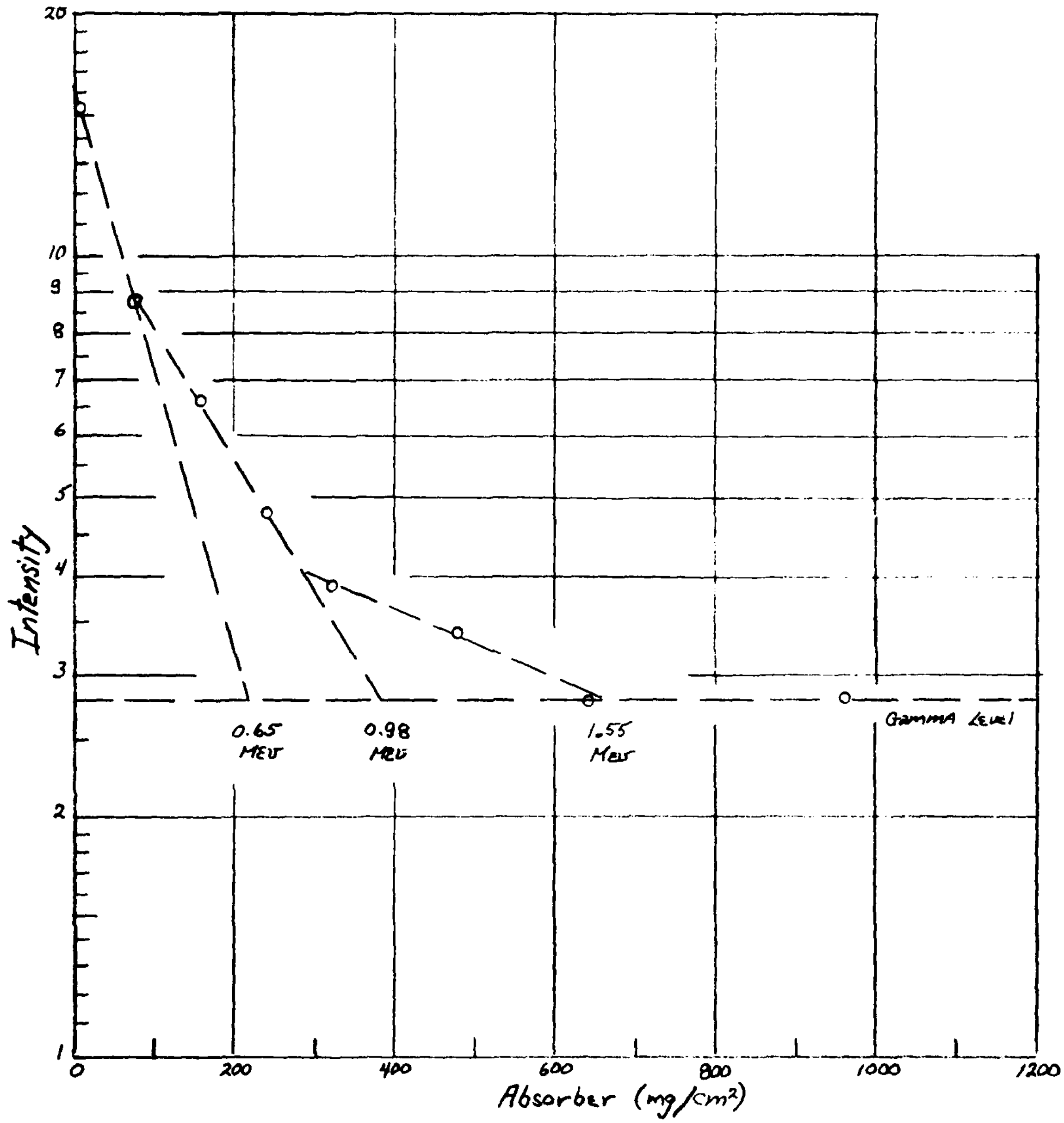

Fig. 22 Beta absorption curves for Turk shot.

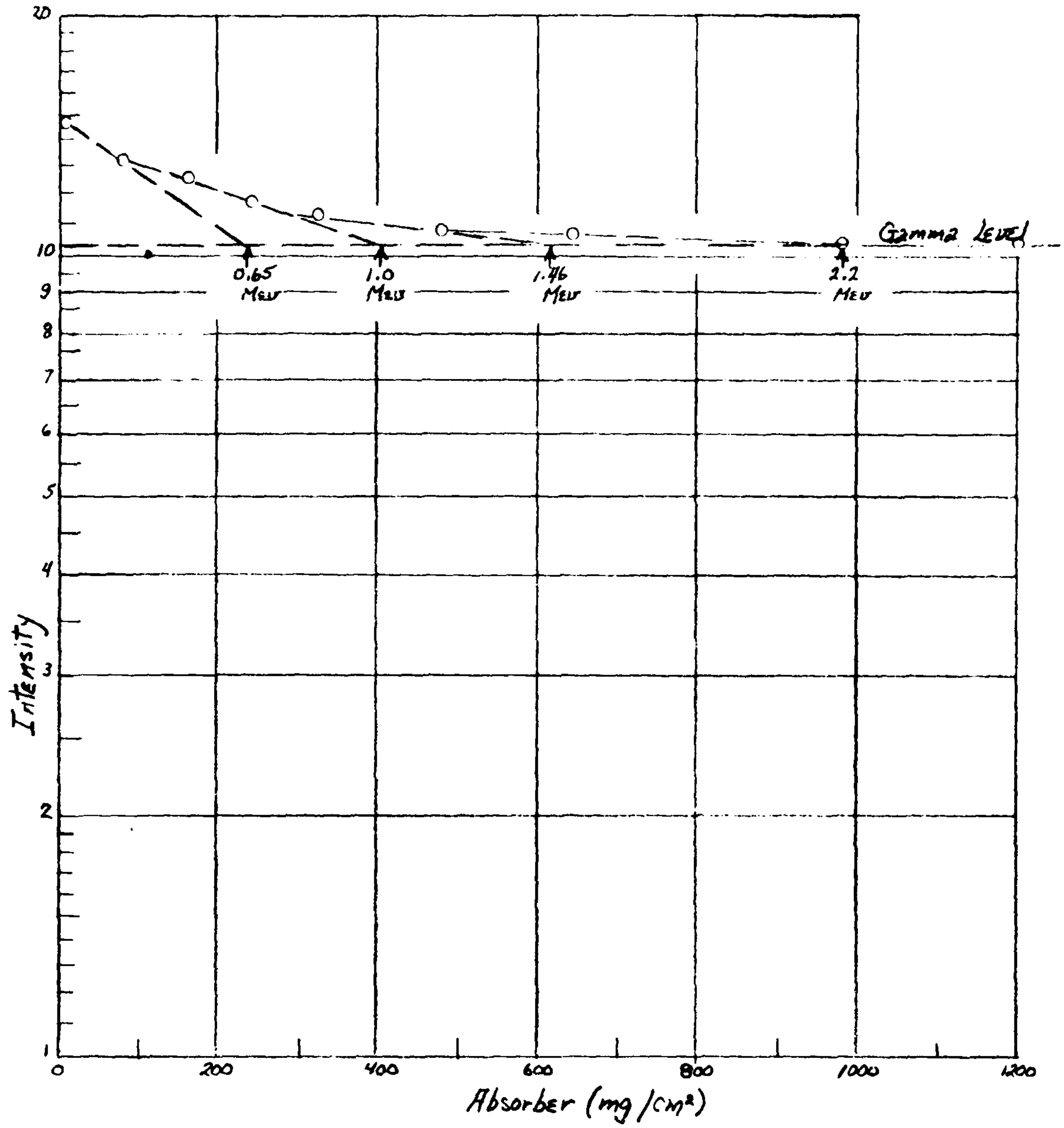

Fig. 23 Beta absorption curves for Hornet shot.

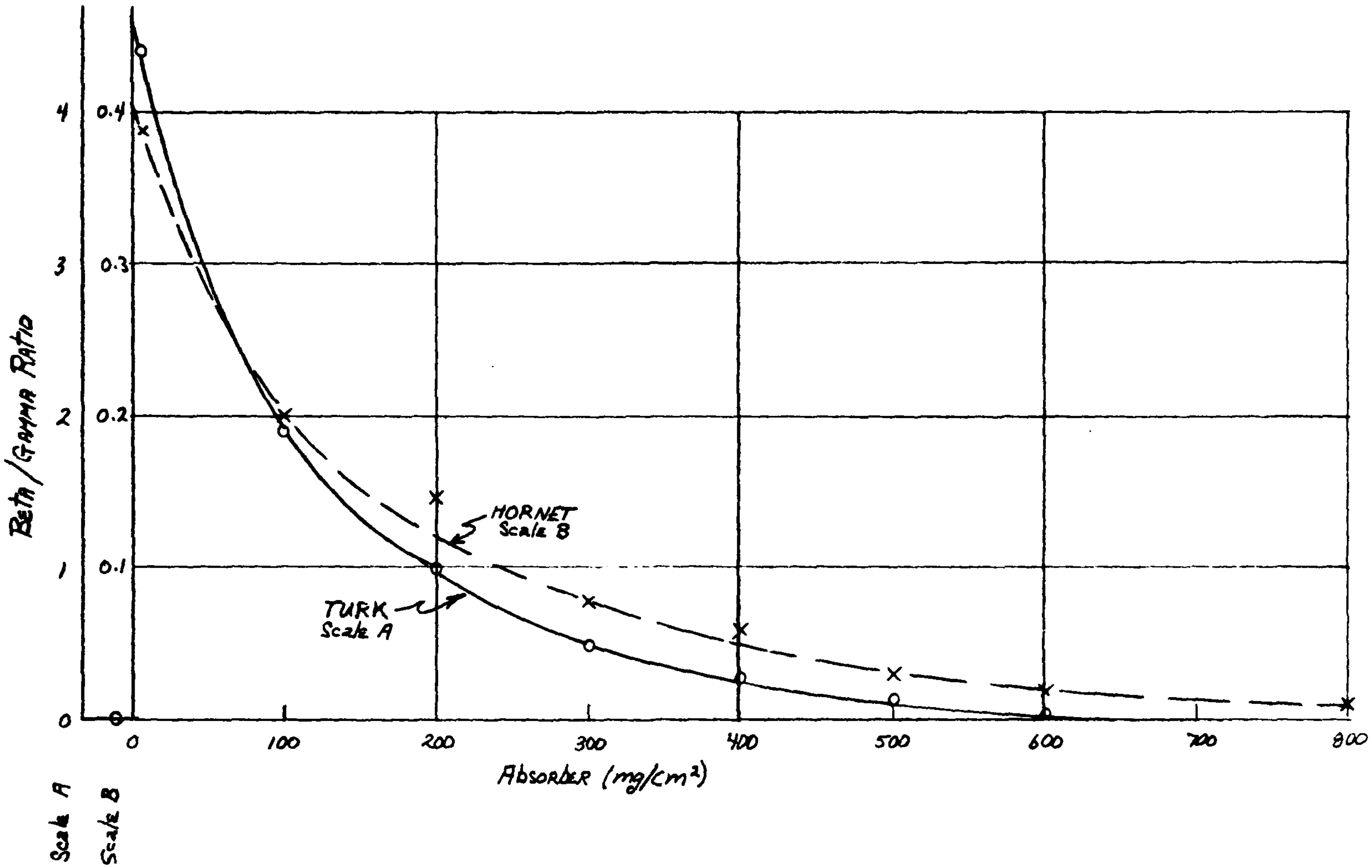

Fig. 24 Beta-gamma ratio in depth.

CHAPTER 4

CONCLUSIONS

4.1 SUMMARY

Instrumentation for aerial surveying was completed and field tested. The results indicate that surveys of large areas may be made rapidly and accurately. The automatic introduction of an altitude correction factor derived from a signal from a radar altimeter eliminated most of the errors due to the change in distance between the plane and the ground terrain. Also, the telemetering facilities transmitted this information to a central plot where it was possible to correlate the results from more than one aircraft.

A study of the constituents of the fall-out indicated a large contribution to the total activity by sodium-24 and other short-lived, neutron-induced isotopes. Since the absorption of gamma photons in air is dependent on photon energy, one expects an altitude correction factor to depend on both time and isotopic distribution. However, the mass absorption of air is nearly linear with energy; thus gross changes in the altitude factor are not indicated. Also, the contribution to the reading in the aircraft by scattering of the hard components of the spectrum may well decrease this variation with time.

While the experimental altitude data taken at Teapot were dependent on source geometry in general, it was possible to confirm previous measurements. The region dependent on the sharp radiation gradients was limited to close proximity to Ground Zero. Ground survey measurements were also difficult due to this condition.

It is expected that the portable gamma spectrum analyzer developed during this period will make it possible to explore in detail the gamma radiation field which the airborne detector experiences. It may well be possible to separate the scatter component from the primary radiation flux.

The beta instrumentation operated well in the field. Such units made it possible to estimate beta contribution to the total activity in the fall-out contaminated areas. The two sets of data taken during the field tests of the equipment agree generally in the beta spectra. However, the Hornet data show an additional high energy beta that was not detected in the Turk data.

4.2 RECOMMENDATIONS

Further study will be necessary to evaluate the accuracy limits of the aerial survey readings. At present it appears this is in the order of ± 20%. Further study of the fall-out debris is necessary to determine the gamma-emitting constituents. A knowledge of these components will allow calculations to be made of altitude correction factors based on air absorption. The experimental measurements may then be used to confirm the results.

The meaning of beta contribution with relation to gamma intensities is not defined. The application of the beta instrumentation will allow further investigation of these characteristics as they are found in actual fall-out-contaminated areas. It is probable that the relationship between beta and gamma depends markedly on both the type of shot and the distance from Ground Zero. However, at present one does not have enough data to attempt any conclusions.

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